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# NUTRITIONAL AND PHYTOCHEMICAL SCREENING OF WILD EDIBLE FRUITS OF WESTERN HIMALAYAS

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**Abstract**

Around the world, wild edible fruits (WEFs) hold an essential place among plants with significant economic and nutrition value. WEFs appear to be used more frequently and extensively in developing and under-developed nations that experience food insecurity. Due to the diversity of bioactive substances found in WEFs, including antioxidants, many species have a significant function in the treatment of various illnesses. The present study is aimed to analyze the nutritional potential and phytochemical composition of some selected fruits from the western Himalayan region. A total of 8 different fruit species are selected; *Berberis lycium, Capsicum frutescens* var. *cerasiforme, Diospyros kaki, Diospyros lotus, Ficus auriculata, Punica protopunica, Zanthoxylum armatum, Ziziphus jujuba.* WEFs are collected from different localities of Western Himalayas and then identified using Flora of Pakistan. Proximate composition including Moisture Content (MC), Ash Content (AC), Crude Fiber (CFr), Crude Fat (CF), Crude Protein (CP), Carbohydrate Content and Total Energy Content were determined using standard methods. Among Phytochemical screening Total Phenolic Content (TPC) and Total Flavonoid Content (TFC) were determined. All the powdered fruit samples were also analyzed under Fourier Transformed Infra-Red (FT-IR) Spectroscopy for further characterization. Among the selected fruits *Ficus auriculata* (88.11±0.1%) contained the highest moisture content whereas *Zanthoxylum armatum* (23.5±0.2%) had quite low moisture content. All fruits are rich source of energy with *Ziziphus jujuba* (425.36±0.32 kcal/100g), *Zanthoxylum armatum* (411.26±0.75 kcal/100g) and *Berberis lycium* (401.1±1.15 kcal/100g) having energy value in the range of 400 kcal/100g. Regarding the phytochemical composition, *Zanthoxylum armatum* had higher values for both phenolics and flavonoids (5.1mg,7.4mg). Specifically, *Berberis lycium* and *Punica protopunica* showed the highest value i.e., 5.6 mg GAE/g-dw for total phenolic content. FT-IR analysis of each fruit sample confirmed its richness in biologically active functional groups.

**Key words:** WEF (Wild edible fruit); Proximate composition; TPC (Total phenolic content; TFC (Total flavonoid content); FT-IR (Fourier transformed infrared spectroscopy)

## Introduction

A sustainable food system is one that ensures food security while providing enough food and nourishment for everyone while maintaining the financial, social, and environmental foundations necessary to produce food security and nutrition for future generations (Amadou & Lawali, 2022). Food security is being defined as when everyone, throughout all times, has physical, social, and economic access to enough, safe, and nutritious food that satisfies their dietary requirements and appetites for a life of wellness and activity, it is what referred by FAO (Mc Carthy *et al.*, 2018). But security of food and nutrition is currently one of the biggest challenges being faced by our planet. According to estimates, two billion individuals worldwide have micronutrient deficiencies that increase their risk of illness. This can be a major barrier to economic growth (Duguma, 2020). Nutrients are essential for the proper functioning of individual, if a person fails to fulfil all his nutritional requirements through food/ diet then it is nutritional inadequacy. Such conditions pose a person to the threat of various diseases that can prove even fatal (Kiani *et al.*, 2022). Eating junk food and the unhealthy items are not the only reason for nutritional deficiencies but there are other reasons as well. The massive growth of population, poverty and both the natural and man-made crises like drought and other pest attacks pose serious challenges to the food security (Buzby & Hyman, 2012). Due to overwhelming increase in population, there is an urgent need for more food and nutrition supplies. When food security is relied exclusively on a small number of traditional sources like house hold animals and agricultural crops, it becomes fragile. Dietary needs and food security

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issues must be dealt with in the perspective of biodiversity which is a valuable resource for domesticating novel crops or we can enhance the quality of crops grown traditionally (Hegazy *et al.*, 2013).

The recognition of the crucial importance of eating a healthier diet by consuming wild plant-based foods must be implemented as the prior strategies and policies and it further increase the variety of foods through the intake of non-conventional plant foods such as wild edible fruits and can also reduce the probability of non-transmitable diseases (Bayang *et al.*, 2021). Wild edible plants are those that are not being cultivated nor domesticated but can grow naturally on farmland and in abandoned or uncultivated areas. Throughout the course of human history, various wild edible plants have been crucial in various parts of the globe. Nowadays, along with the utilization of staple crops wild plants have also been consumed by the local of many areas especially rural ones to achieve nutritional values and to attain a healthy life. One can also improve financial conditions through the exchange or selling of plants or plant products. According to an estimate about one billion people from all over the world consume the food derived from the wild plants (Lulekal *et al.*, 2011; Duguma, 2020).

Despite being used traditionally, wild plants also have nutritional values. They are considered to be the rich resource of minerals and macro and micro nutrients like sodium, potassium, calcium, magnesium, iron and many others. Macro molecules like carbohydrates, fats and proteins are also present in abundance (Deshmukh & Waghmode, 2011). Wild plants can maintain a healthy and balanced diet by providing the essential nutrients and thus they can easily overcome the problems of hunger and malnutrition (Bvenura & Sivakumar, 2017). Further, wild foods may add variety and flavor to the diet, making them a necessary component of a bland and nutritionally deficient diet (Fentahun & Hager, 2009).

Current eating practices are now redefining our understanding of health. Our understanding of the significance of nutrition is evolving as a result of new information about how diet affects genetic and molecular regulation (Biesalski *et al.*, 2009). Wild plants are not only nutritionally active but also contain various anti-oxidants called as “bioactive compounds”. These extra-nutritional components also known as "bioactive compounds" are usually found in foods in trace amounts. Common anti-oxidants are phenol, flavonoids, terpenoids etc. their presence make such plants important for therapeutic or medicinal purposes. For example, Soy, flax seed oil, grains and many other fruits and vegetable contain different phytoestrogen (an anti-oxidant compound) which gives positive impact on people who are at the risk of cardiovascular diseases (Kris-Etherton *et al.*, 2002). Various kinds of herbal medicines derived from such plants are frequently utilized by the people in rural areas of the developing and under developed nations (Roosita *et al.*, 2008). Due to modernization and the propensity to abandon their old lifestyle, the understanding of traditional therapeutic methods employing wild herbs is now quickly vanishing (Katewa *et al.*, 2004) but still rural communities prefer using plant-based medicines as they are the budget friendly, alternate to the otherwise expensive medicines (Hazarika *et al.*, 2012). Finding an alternative medical system for the treatment of diseases with ever-changing nature is crucial in the context of today's methods of disease cure, especially for those that do not require prolonged therapy and can be cured by using herbal products (Baquar, 1989).

Traditional herbal remedies (THM) have proven successful in treating a variety of illnesses (Mukherjee & Wahile, 2006). Various fruits are consumed either raw or after processing through multiple steps to cure different kinds of diseases. The fruit of Wild Medlar (*Mespilus germanica L.*) is considered as diuretic and is effective to remove the stones from kidney and urinary bladder (Khan *et al.*, 2015). likewise *Morus alba, Punica granatum, Raphanus sativus* and many other plants are used to treat the ailments like jaundice and hepatitis (Abbasi *et al.*, 2009).

The sale of wild edible fruits is beneficial in financial terms as they can generate the income for the household expenses (Suwardi *et al.*, 2020). Wild plants are thought to be necessary to maintain rural livelihoods, decrease impoverishment rates, and boost economic development (Suwardi *et al.*, 2022). Herbal medicines are exchanged in the herbal marketplaces, which are the important cultural hubs for the human societies (de Albuquerque *et al.*, 2007). Further, wild fruits can also be used as fuel, fodder, colours, resins, building materials, cure for fish poisoning, and source of essential oils (Hazarika & Pongener, 2018).

Consequently, ethno-directed research tries to discover novel treatments, increase the food resources and conserving them and can be helpful in the documenting and identification of these species (Ul Abidin *et al.*, 2023).

**The current study aims:** 1. To investigate the nutritional importance and the composition of some phytochemicals in selected wild edible fruits collected from western Himalayas. 2. To analyze the chemical compounds in fruits through FT-IR spectroscopy. 3. To highlight medical uses of these wild edible fruits from the literature cited.

## Materials and Method

**Study area:** The plants for the nutraceutical studies were collected from the northern areas of Pakistan mainly Mansehra (Tehsil Oghi) 34.5°N, 73.2°E and Kashmir (district Bagh 33.9°N, 73.8°E and Mang Sudhnoti 33.7°N, 73.9°E). North Pakistan is situated at the top of the three highest mountain ranges on Earth, the Himalaya, Hindukush, and Karakorum, giving it a special biogeographic position. With significant percentages of endemic and uncommon species, these ranges are home to the hotspots of floral and faunal variety (Ullah *et al.*, 2015).

**Collection and preparation of samples:** The edible fruits of wild plants were collected from Mansehra and Kashmir. In total 8 different plant species were collected from different sites namely *Berberis lycium* Royle*, Capsicum frutescens* var. *cerasiforme* (Mill.) L.H. Bailey*, Diospyros kaki* L.*, Diospyros lotus* L.*, Ficus auriculata* Lour.*, Punica protopunica* Balf.f.*, Zanthoxylum armatum* DC.*, Ziziphus jujuba* Mill. This field work was carried out in the month of August to September. Plants were photographed during the field. Approximately 500g to 1 kg of fruit samples were collected from each plant depending on their nature. These samples were identified and then stored in the polythene bags. A voucher for each sample was deposited in Herbarium of Pakistan (ISL), Quaid-i-Azam University, Islamabad. Fruit samples were processed for the preservation and analyzed by using the standard techniques.

Every sample was properly cleaned to get rid of any dirt or other contaminants that may have attached (Mahapatra *et al.*, 2012). Fruits were peeled and seeds were separated from the edible portion where necessary. The edible portion was weighed and then shade dried or dried in oven at about 60°C until obtain a constant weight. After being dried the samples were again weighed and ground to a fine powdered form using mortar and pestle and then by sieving technique. The powder thus obtained was preserved in the air tight plastic bags for further analysis (Elinge *et al.*, 2012). The detail about the fruits collected are presented in Table 1 and their condition at collection, dried and powdered stage is shown in Fig. 1.

The wild edible fruits are collected for their numerous uses especially for medicinal purpose. Their medicinal uses as cited from previous papers (Yamamoto & Nawata, 2009; Saklani & Chandra, 2012; Kapoor *et al*., 2013; Grygorieva *et al*., 2014; Rauf *et al*., 2017; Phuyal *et al*., 2019; Guerrero-Solano *et al*., 2020; Ibrahimova *et al*., 2020) are presented in Table 2.

**Determination of proximate composition:** The proximate composition of wild edible fruits is analyzed using the standard protocol as given by AOAC (Association of Official Analytical Chemists).

The moisture content of the fruit samples was analyzed by placing the fruits of known weight in the oven at 60°C until the continuous weight was obtained. After oven drying, the samples were reweighed. The difference in weight represented the moisture content (Mali & Harsh, 2015). It could be calculated by the method given by (Ys & Op, 2018).

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

Ash content of the sample was evaluated in silica crucibles by igniting 1g each of dried fruit in powder form for 5 hours at 550–600°C in a muffle furnace (Model LMF Series OMEGA). After cooling, sample was weighed. Ash was determined by difference method (Kumar *et al.*, 2016). It was calculated by given formula (Barwant & Lavhate, 2020).

$$\text{Ash content (\%)} = \frac{\text{Weight of ash (W2} - \text{W1)}}{\text{Weight of sample}} \times 100$$

W1 = Weight of empty crucible
W2 = Weight of crucible containing ash

**Table 1. List of collected fruits.**

| S. No. | Specie name | English name | Local name | Family | Collection site | Habit |
|---|---|---|---|---|---|---|
| 1. | *Berberis lycium* | Barberry | Sumbal | Berberidaceae | Mang Sudhnoti, Kashmir | Shrub |
| 2. | *Capsicum frutescens* var. *cerasiforme* | Cherry pepper | Pahadi mirch | Solanaceae | Bagh, Kashmir | Shrub |
| 3. | *Diospyros kaki* | Japanese Persimmon | Amlok | Ebenaceae | Oghi, Mansehra | Tree |
| 4. | *Diospyros lotus* | Date plum | Tor amlook | Ebenaceae | Bagh, Kashmir | Tree |
| 5. | *Ficus auriculata* | Roxburgh fig | Injeer | Moraceae | Oghi, Mansehra | Tree |
| 6. | *Punica protopunica* | Pomegranate | Daruna | Lythraceae | Oghi, Mansehra | Tree |
| 7. | *Zanthoxylum armatum* | Winged prickly ash | Timbur | Rutaceae | Oghi, Mansehra | Shrub |
| 8. | *Ziziphus jujuba* | Chinese date | Sinjlian | Rhamanaceae | Oghi, Mansehra | Tree |

**Table 2. Medicinal uses of selected wild edible fruits.**

| Plant name | Medicinal uses |
|---|---|
| *Berberis lycium* | It is used to treat obesity, piles, hemorrhoids, dysentery, indigestion, uterine disorders and other eye complaints. Decoction obtained from fruit helps reduce fever. Also, the berberine, an alkaloid, have anti-tumor properties (Kapoor *et al.*, 2013). |
| *Capsicum frutescens* | It is a medication for diarrhea, stomachaches, joint discomfort, and hunger stimulation. It also prevents bacteria from growing (Yamamoto & Nawata, 2009). |
| *Diospyros kaki* | It is used to treat diseases like cough, dyspnea. It is an antihypertensive agent. It prolongs life and lowers brain hemorrhage and infarction in stroke, inhibits lipid peroxidation, and acts as an antioxidant. Fruits of this plant also show detoxifying properties (Rauf *et al*., 2017). |
| *Diospyros lotus* | They help to treat anemia, liver disorders and also healing of wounds. The seeds contain sedative properties and utilized for making herbal teas that can give relief from hypertension (Ibrahimova *et al*., n.d.). |
| *Ficus auriculata* | They are used against various neurodegenerative and hepatic diseases due to strong antioxidant properties. Paste of leaves, stem bark juice is used to treat wounds as well as diarrhea and dysentery. Roasted figs are also consumed for being effective against diarrhea and dysentery. Root latex is good to treat cholera and vomiting (Saklani & Chandra, 2012). |
| *Punica protopunica* | They are effective against various diseases such as ulcers, diarrhea, dysentery, sores and wounds, urinary tract infections, dry coughs, jaundice, skin conditions and other digestive issues. It has high medicinal properties due to its anthelmintic and anti-diabetic traits (Guerrero-Solano *et al*., 2020). |
| *Zanthoxylum armatum* | This plant is rich in antibacterial, antiviral, hepato-protective and many other qualities. Fruits and seeds are very effective against many ailments like cholera, toothache, stomach problems, fever, dyspepsia etc. (Phuyal *et al*., 2019). |
| *Ziziphus jujuba* | They can cure a number of diseases including liver diseases, respiratory diseases, digestive disorder, skin infection, brain nerve disorders, diabetes, fever, weakness, insomnia and urinary problems. They are very effective for consumption because of numerous qualities such as immunostimulatory, hypotonic, anticancer, antifungal, antibacterial, anti-inflammatory, and antioxidant (Grygorieva *et al*., 2014). |


Fig. 1. Collected wild edible fruits.
*Berberis lycium (*a; plant, b; dried fruit, c; powdered form), *Capsicum frutescens var. cerasiforme (*d; plant, e; dried fruit, f; powdered form), *Diospyros kaki (*g; plant, h; dried fruit, i; powdered form), *Diospyros lotus (*j; plant, k; dried fruit, l; powdered form), *Ficus auriculata (*m; plant, n; dried fruit, o; powdered form), *Punica protopunica (*p; plant, q; dried fruit, r; powdered form), *Zanthoxylum armatum (*s; plant, t; dried fruit, u; powdered form), *Ziziphus jujuba (*v; plant, w; dried fruit, x; powdered form).

The amount of fiber was determined by measuring the weight loss upon the combustion of dried residue after fat-free samples were digested using solutions containing 1.25% sulfuric acid and sodium hydroxide i.e. acidic and basic digestion respectively (Hegazy *et al.*, 2013). In acidic digestion 1g of samples obtained after fat extraction was boiled in $H_2SO_4$ for 30 minutes and then filtered. This residue obtained after filtration was then used in basic digestion. In basic digestion, the filtered residue was boiled in NaOH for 30 minutes. It was then filtered again and the residue was ignited in furnace. The ash thus obtained was weighed.

$$\text{Fiber content (\%)} = \frac{(W2 - W1) - (W3 - W1)}{\text{Weight of defatted sample}} \times 100$$

W1 = Weight of empty crucible
W2 = Weight of crucible + dry residue
W3 = Weight of crucible and sample after ignition

The Soxhlet extraction method according to AOAC (Association of Official Analytical Chemists) was used to calculate the fat content. Soxhlet apparatus (Behr labor-Technik EZ 100H) was used for fat extraction purpose. 5g of sample was weighed and placed in Whatman No. 2 filter paper, then put into a dry extraction thimble, which was put within a Soxhlet extraction tube. n-Hexane was used for extraction purpose. This procedure takes almost 5-5.30 hours (Yiblet & Adamu, 2023).

$$\text{Fat content (\%)} = \frac{(T2 - T1) - (T3 - T1)}{\text{Weight of sample}} \times 100$$

T1 = Weight of empty thimble
T2 = Weight of thimble + sample
T3 = Weight of thimble after processing

Protein performs essential structural and functional role in body so their presence in food is very significant. Crude protein in sample was analyzed by determining the nitrogen content using kjeldahl method and then estimating the protein content by multiplying the nitrogen content with conversion factor i.e., 6.25. The kjeldahl method (Sáez-Plaza *et al.*, 2013), including three steps i.e. digestion, distillation, titration was followed.

$$\text{Nitrogen content (\%)} = \frac{\text{Titration value} \times 0.1 \times 0.014 \times \text{Dilution factor}}{\text{Weight of sample}} \times 100$$

$$\text{Crude protein (\%)} = \text{\% Nitrogen} \times 6.25$$

The carbohydrate contents of the selected fruits are estimated as: (Seal, 2011).

$$\text{Total carbohydrate (\%)} = 100 - (\text{\% Protein} + \text{\% Fat} + \text{\% Fiber} + \text{\% Ash})$$

The total energy content of food was determined (Angami *et al.*, 2024) and expressed as Kcal 100 g−1 dry basis by using the following formula:

$$\text{Total energy} = (\text{\% Carbohydrates} \times 4) + (\text{\% Fat} \times 9) + (\text{\% Protein} \times 4)$$

**Phytochemical analysis:** Flavonoids and phenols are multipurpose bioactive substances that have anti-inflammatory, antibacterial, antioxidant, and anti-cancer properties. Numerous investigations have established that the antioxidant effect of plant extracts is mostly attributed to these multifunctional bioactive substances (Shahidi & Ambigaipalan, 2015).

**Determination of total phenolic content:** The method of (Li *et al.*, 2007) was utilized to ascertain the total phenolic content. 1ml of diluted Folin-Ciocalteu reagent (diluted ten times with distilled water) was combined with two hundred µL of the plant extract. 800 µL of Na2CO3 (75 g/L) were added after 4 minutes. At room temperature, the absorbance was measured at 765 nm after two hours of incubation with the help of UV-Visible spectrophotometer. The calibration curve for standard use contained gallic acid. Gallic acid equivalents (GAE) per gram of extract (mg GAE/g) were used to express the results. Every test was run in triplicate.

**Determination of total flavonoid content:** The method of determining flavonoid content as outlined by (Shraim *et al.*, 2021) was used. 1ml of plant extract, 1ml of quercetin methanolic solution, and 1ml of aluminum trichloride solution (2% in methanol) were combined to create the quercetin calibration curve. At 415 nm, absorbance was recorded ten minutes later with the help of UV-Visible spectrophotometer. Quercetin equivalents (QE) per gram of extract (mg QE/g) were used to express the results. Every sample went through triplicate preparation and analysis.

**FT-IR analysis:** FT-IR (Fourier Transformed Infra-red) spectroscopy analysis aids in the determination of the chemical composition, the clarification of the chemical structure, and the comprehension of the significance of functional groups in Phyto-pharmaceutical formulations as bioactive molecules (Ralte *et al.*, 2021). On a Perkin-Elmer FT-IR, the powdered fruit samples were individually treated to Fourier transform infrared (FT-IR) spectroscopy (mid-IR spectra). After doing the experiments, the spectrum from 4000 to 400 cm−1 was recorded. To identify the functional groups that were present, the peak frequencies were assessed against the reference literature.

## Results and Discussion

**Proximate characterization:** Proximate analysis included moisture content, ash content, crude fibre content, crude fat content, crude protein content, carbohydrate content and estimated energy value. Moisture content was calculated as % of fresh fruit (Table 3). Whereas all other parameters were presented as % dry matter except energy content which was calculated in kcal 100g-1 dry basis.

Since various physical characteristics of fruit are strongly associated with moisture content, fruit's moisture content is vital (Fraser *et al.*, 1978). The primary component of fresh fruits and vegetables is water, which keeps them turgid. The moisture content of the selected plants ranged from 23.5–88.11% on fresh weigh basis. The highest moisture content was recorded in *Ficus auriculata* (88.11±0.1%) followed by *Diospyros kaki, Berberis lycium, Capsicum frutescens, Ziziphus jujuba, Punica*

*protopunica, Diospyros lotus*. *Zanthoxylum armatum* had lowest moisture value (23.5±0.2%). The calculated moisture content of the fruits of *Ficus auriculata* was closer to the moisture amount presented by (Shrestha *et al.*, 2023) which is 83.58±0.58%. Results of (Khaing & Moe, 2021) also showed a lower value for moisture content of *Zanthoxylum armatum* i.e.12.68%. The lower moisture value of *Z. armatum* is effective as would be easy to dry them immediately after they were harvested and hence could be stored for long term uses (Cheng *et al.*, 2021).

A crucial initial step in proximal or particular mineral analysis is ash determination. Ash is the term for the inorganic (mineral) residue that is left over after food's organic substance (i.e. carbohydrates, protein, fats) has burned or completely oxidized (Harris & Marshall, 2017). The ash content of the selected plants ranged from 25.6-2.87% of dry matter. The higher ash value was reported in *Ficus auriculata* (25.6±0.36) followed by *Punica protopunica, Capsicum frutescens* var. *cerasiforme, Diospyros kaki, Zanthoxylum armatum, Berberis lycium, Diospyros lotus* respectively. *Ziziphus jujuba* has the lowest ash value (2.87±0.15). Comparison of the nutritional value of *Ficus auriculata* to the previous studies shows our ash value was slightly higher than reported by (Shrestha *et al.*, 2023) their ash value was 1.45±0.04% of fresh weight which becomes 23.8% of dry matter. Ash value of *Ziziphus jujuba* was also slightly higher than (Akbolat *et al.*, 2008) who report it to be 2%. The diversity of plants, varying growth environments, or variations in analysis techniques could all be contributing participants to these variations in nutrient content (Shrestha *et al.*, 2023).

Dietary fibers play a key role in nutrition as they can reduce the risks of various diseases. Plants are main source of fibers in our diet (Ramulu & Rao, 2003). The fibre content of the selected plants ranged from 20-5% of dry matter. The highest fiber value was reported in *Punica protopunica* (20±0.12) followed by *Capsicum frutescens var. cerasiforme, Diospyros kaki, Zanthoxylum armatum, Ficus auriculata, Diospyros lotus, Ziziphus jujuba* respectively. *Berberis lycium* had lowest fibre value (5±0.08). Higher fibre value in the fruit peels of *Punica protopunica* (31.50±1.16) was reported by Shah *et al*., (2022). The difference in reading might be due to difference in parameter i.e. peels and seeds. Awan *et al*., (2014) presented lower crude fiber values in other species of *Berberis* as well.

The crude fat value obtained in this study ranges from 18.3±0.3% dry matter to 4.8±0.2% dry matter of *Zanthoxylum armatum* and *Diospyros kaki* respectively. Research on the crude fat content of *Zanthoxylum armatum* is limited. But its value can vary upon the growing conditions and geographical area. The lower fat value of *Diospyros kaki* is also reported by Lucas-González *et al.*, (2017).

The crude protein value of the studied fruits samples ranges from 8.74±0.07% to 0.95±0.07% of dry matter of *Punica protopunica* and *Capsicum frutescens var. cerasiforme* respectively. Protein content was also found to be higher in the peels of *Punica protopunica* by (Shah *et al.*, 2022). There is no evaluation of proximate composition of *Capsicum frutescens var. cerasiforme*. Studies of other *Capsicum frutescens* varieties has shown that their protein value is lower than other *Capsicum* species as reported in (Olatunji & Afolayan, 2020).

The calculation of carbohydrate contents among the selected fruits showed that it is highest in *Berberis lycium* (74.06±0.115% of dry matter) where (Sood *et al.*, 2010) also reported similar values for carbohydrate contents of this plant was 12.64% of fresh weight and approximately it was 75.64% of dry matter. whereas *Punica protopunica* presents the lowest value i.e. 41.7±0.75% of dry matter which is closer to the data presented by (Shah *et al.*, 2022) that worked on *Punica protopunica* fruit peels.

Among the selected fruits *Ziziphus jujuba* presents the highest energy value of 425.36±0.32 kcal/100g whereas, energy content of *Punica protopunica* is lowest among them with a value of 286.4±3.04 kcal/100g. As all the fruits processed are in dried form so they present high caloric value than the fresh fruits due to reduced water content.

**Table 3. Proximate composition of selected wild edible fruits.**

| S. No. | Fruit species | Moisture content (%) | Ash content (% DM) | Fibre content (% DM) | Fat content (% DM) | Protein content (% DM) | Carbohydrate content (% DM) | Energy content (kcal/100g) |
|---|---|---|---|---|---|---|---|---|
| 1. | *Berberis lycium* | 83.37 ± 0.25 | 5.1 ± 0.08 | 5 ± 0.08 | 8.3 ± 0.1 | 7.54 ± 0.1 | 74.06 ± 0.115 | 401.1 ± 1.15 |
| 2. | *Capsicum frutescens* | 76.9 ± 0.1 | 20.06 ± 0.8 | 19 ± 0.1 | 15.5 ± 0.1 | 0.95 ± 0.07 | 44.48 ± 0.83 | 321.2 ± 2.8 |
| 3. | *Diospyros kaki* | 83.12 ± 0.1 | 16.09 ± 0.07 | 13.2 ± 0.2 | 4.8 ± 0.2 | 2.25 ± 0.07 | 63.66 ± 0.32 | 306.8 ± 1.47 |
| 4. | *Diospyros lotus* | 59 ± 0.4 | 4.9 ± 0.1 | 9.13 ± 0.12 | 8.19 ± 0.2 | 3.95 ± 0.02 | 73.84 ± 0.18 | 384.8 ± 1.07 |
| 5. | *Ficus auriculata* | 88.11 ± 0.1 | 25.6 ± 0.36 | 12.9 ± 0.1 | 9.96 ± 0.15 | 2.18 ± 0.03 | 49.36 ± 0.37 | 295.8 ± 2.47 |
| 6. | *Punica protopunica* | 67.3 ± 0.3 | 20.13 ± 0.7 | 20 ± 0.12 | 9.4 ± 0.1 | 8.74 ± 0.07 | 41.7 ± 0.75 | 286.4 ± 3.04 |
| 7. | *Zanthoxylum armatum* | 23.5 ± 0.2 | 7.13 ± 0.15 | 12.96 ± 0.35 | 18.3 ± 0.3 | 1.09 ± 0.03 | 60.47 ± 0.49 | 411.26 ± 0.75 |
| 8. | *Ziziphus jujuba* | 71.43 ± 0.4 | 2.87 ± 0.15 | 8.16 ± 0.15 | 13.9 ± 0.1 | 6.61 ± 0.045 | 68.46 ± 0.19 | 425.36 ± 0.32 |

**Table 4. phytochemical composition of selected wild edible fruits.**

| S. No. | Fruit species | TPC (mg GAE/g-dw) | TFC (mg QE/g-dw) |
|---|---|---|---|
| 1. | *Berberis lycium* | 5.6 | 4.35 |
| 2. | *Capsicum frutescens* | 4.14 | 4.09 |
| 3. | *Diospyros kaki* | 2.96 | 3.45 |
| 4. | *Diospyros lotus* | 4.4 | 3.25 |
| 5. | *Ficus auriculata* | 3.26 | 4.85 |
| 6. | *Punica protopunica* | 5.6 | 3.7 |
| 7. | *Zanthoxylum armatum* | 5.1 | 7.4 |
| 8. | *Ziziphus jujuba* | 4 | 3.2 |

**Phytochemical composition:** Analysis of total phenolic and flavonoid content, was carried out for the fruit samples. Total phenolic content ranges from 5.6-2.96 mg GAE/g-dw. the highest value was recorded in two species namely *Berberis lycium* and *Punica protopunica.* Whereas, *Diospyros kaki* shows the lowest value. Results from TPC analyses utilizing various extract concentrations, techniques, and even reference solutions (gallic acid) are likely to vary (Table 4). The geographic origin, cultivar, harvest, storage period, drying and extraction techniques, and harvest timing may all have an impact on the total phenolic content.

Phenolics' capacity to chelate metals, inhibit lipoxygenase, and scavenge free radicals may be linked to their bioactivity (Babbar *et al.*, 2011). Among the total flavonoid content of selected fruits, the range is 7.4-3.2 mg QE/g. *Zanthoxylum armatum* has the highest value and *Ziziphus jujuba* exhibited the lowest value. (Barkatullah *et al.*, 2012) reported a significantly higher value for the fruits of *Zanthoxylum armatum* with a value of 22.8 mg/g.

**FT-IR characterization:** All the fruits samples are analysed under Fourier transformed infrared (FTIR) spectroscopy under the range of 4000-400 cm-1 (Table 5). All samples represent the characteristic absorption peaks of alcohols, amines, esters, carboxylic acids, phenols, alkanes and other compounds indicating the presence of carbohydrates, proteins (variety of amino acids), fatty acids, triglycerides, phenolic compounds etc. *Ficus auriculata* and *Zanthoxylum armatum,* however, show a distinctive peak of sulphonyl group or sulphones. Sulphonyl containing compound are very important for their immense application in the field of medicines and agrochemical. The sulphonyl groups consist of various type of bioactive compounds having immense medical significance such compounds are mesotrione, eletriptan, bicalutamide etc. (Hofman *et al.*, 2018). The FTIR spectrum of *Ziziphus jujuba* shows the presence of α, β-unsaturated ketones. Such compound are key elements involved in the covalent binding of natural ligands in Peroxisome proliferator-activated receptor γ (PPARγ). These receptors are essential for various biological processes (Shiraki *et al.*, 2005). Variety of compounds are detected in selected fruit samples.

The FTIR spectra of fruit of *Berberis lycium* as shown in Fig. 2 presents the characteristics absorption bands at 3275.69cm-1, 2920.49cm-1, 1725.42cm-1, 1411.88cm-1, 1342.72cm-1, 1243.70cm-1, 1023.69cm-1, and 690-515cm-1. The absorbance at 3275.69cm-1 shows N-H stretching that indicates aliphatic primary amine whereas weak absorption of 2920.49cm-1 was the O-H stretch of alcohol. The 1725.42cm-1 absorption indicates the C-H bonds of aromatic compound. Absorption at 1411.88cm-1 represents the O-H stretch of carboxylic acid. The absorbance at 1342.72cm-1 shows the O-H bending of phenol and 1243.70cm-1 is C-N of amines. The strong absorption of 1023.69cm-1 represents the C-O stretching indicating the presence of vinyl ether and alkyl aryl ether. The absorption bands between the 690 to 515cm-1 shows the C-Br of halo compounds. (Mehmood *et al.*, 2016) also reports similar types of compounds but from the root extracts of *Berberis* using FT-IR spectroscopy.

**Table 5. FT-IR analysis.**

| Plant name | FT-IR analysis |
|---|---|
| *Berberis lycium* | 3275.69cm-1=N-H stretching that indicates aliphatic primary amine. 2920.49cm-1= O-H stretch of alcohol. 1725.42cm-1= C-H bonds of aromatic compound. 1411.88cm-1= O-H stretch of carboxylic acid.1342.72cm-1=O-H bending of phenol and 1243.70cm-1=C-N of amines.1023.69cm-1=C-O stretching that indicates vinyl ether and alkyl aryl ether. 690 to 515cm-1=C-Br of halo compounds. |
| *Capsicum frutescens* var. *cerasiforme* | 3277.45cm-1=N-H stretching that indicates aliphatic primary amine. 2923.08cm-1=O-H stretch of alcohol. 1743.30cm-1= C=O bonds of esters. 1629.78cm-1=N-H bend of amines. 1377.62cm-1=O-H bending of phenol and 1238.04cm-1=C-N of amines. 1157.70cm-1=C-O of tertiary alcohol. 1030.40cm-1=C-O stretching that indicates vinyl ether and alkyl aryl ether. 690 to 515cm-1=C-Br of halo compounds. |
| *Diospyros kaki* | 3270.97cm-1=N-H stretching that indicates aliphatic primary amine. 2980.96cm-1=O-H stretch of alcohol. 1607.32cm-1=C-H bonds of aromatic compound. 1342.10cm-1=O-H bending of phenol and 1239.07cm-1=C-N of amines. 1022.95cm-1=C-O stretching that indicates vinyl ether and alkyl aryl ether. 773.36cm-1=C=C of alkenes. 690 to 515cm-1=C-Br of halo compounds. |
| *Diospyros lotus* | 3281.59cm-1=N-H stretching that indicates aliphatic primary amine. 2981.00cm-1=O-H stretch of alcohol. 1606.32cm-1=C-H bonds of aromatic compound. 1379.09cm-1=O-H bending of phenol and 1232.74cm-1=C-N of amines. 1026.12cm-1=C-O stretching that indicates vinyl ether and alkyl aryl ether. 816.48cm-1= C=C of alkenes. 690 to 515cm-1=C-Br of halo compounds. |
| *Ficus auriculata* | 3272.04cm-1=N-H stretching that indicates aliphatic primary amine. 2980.97cm-1=O-H stretch of alcohol. 2850.40cm-1=C-H bond of alkane. 1603.11cm-1=C-H bonds of aromatic compound. 1380.32cm-1= S=O stretching of sulphonyl chloride and 1249.37cm-1=C-N of amines. 1012.44cm-1=C-F stretching that indicates the presence of fluoro compounds. 690 to 515cm-1=C-Br of halo compounds |
| *Punica protopunica* | 3282.83cm-1=N-H stretching that indicates aliphatic primary amine. 2924.77cm-1=O-H stretch of alcohol. 1740.53cm-1=the stretching of esters and aldehydes. 1635.02cm-1= C=C bonds of conjugated alkenes. 1029.73cm-1= C-O stretching that indicates vinyl ether and alkyl aryl ether. 987.88cm-1=bending of C=C of mono-substituted alkenes. 690 to 515cm-1= C-Br of halo compounds. |
| *Zanthoxylum armatum* | 3283.10cm-1=N-H stretching that indicates aliphatic primary amine. 2980.83cm-1=O-H stretch of alcohol. 1742.98cm-1= C=O bond of esters. 1614.29cm-1= C=C bonds of aromatic alkenes. 1379.02cm-1=O-H bending of phenol and 1241.67cm-1=C-N of amines. 1154.91cm-1= S=O of sulphonic acid or sulphones. 1026.92cm-1=C-O stretching that indicates vinyl ether and alkyl aryl ether. 690 to 515cm-1=C-Br of halo compounds. |
| *Ziziphus jujuba* | 3276.22cm-1=N-H stretching that indicates aliphatic primary amine. 2925.50cm-1=O-H stretch of alcohol. 1615.06cm-1= C=C bonds of α, β-unsaturated ketones. 1407.37cm-1= S=O stretching of sulphonyl chloride and 1239.22cm-1=C-N of amines. 1024.51cm-1=C-O stretching that indicates vinyl ether and alkyl aryl ether. 817.16cm-1=C-Cl stretching of halo compound. 776.03cm-1= C=C of alkenes. 690 to 515cm-1=C-Br of halo compounds. |

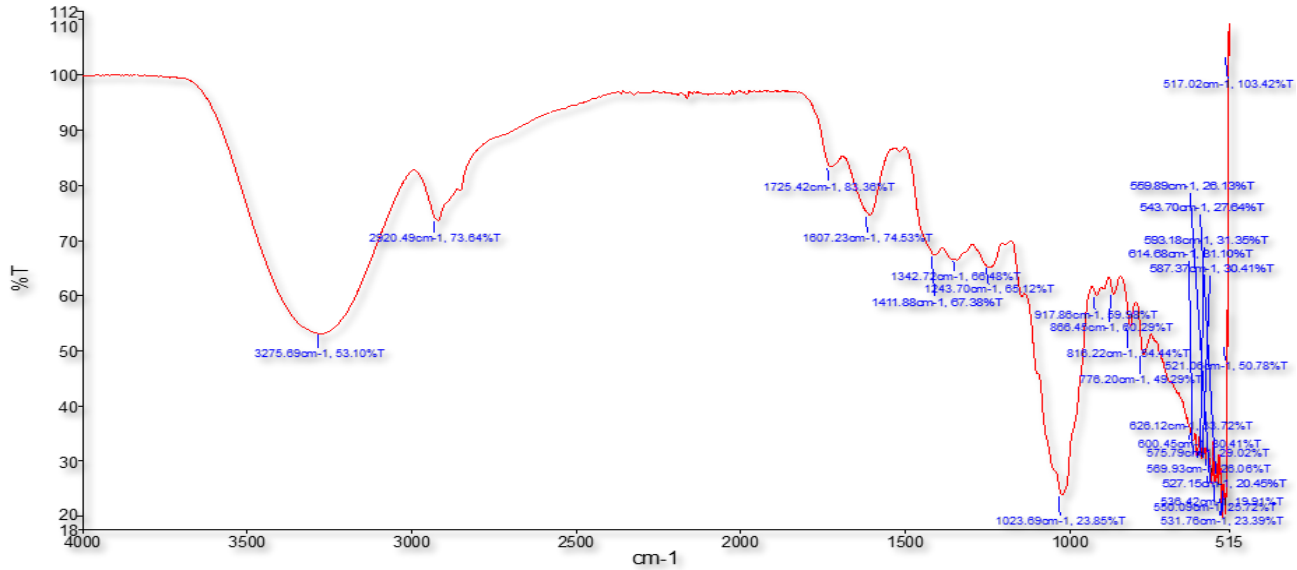


Fig. 2. FT-IR spectra of *Berberis lyceum*.

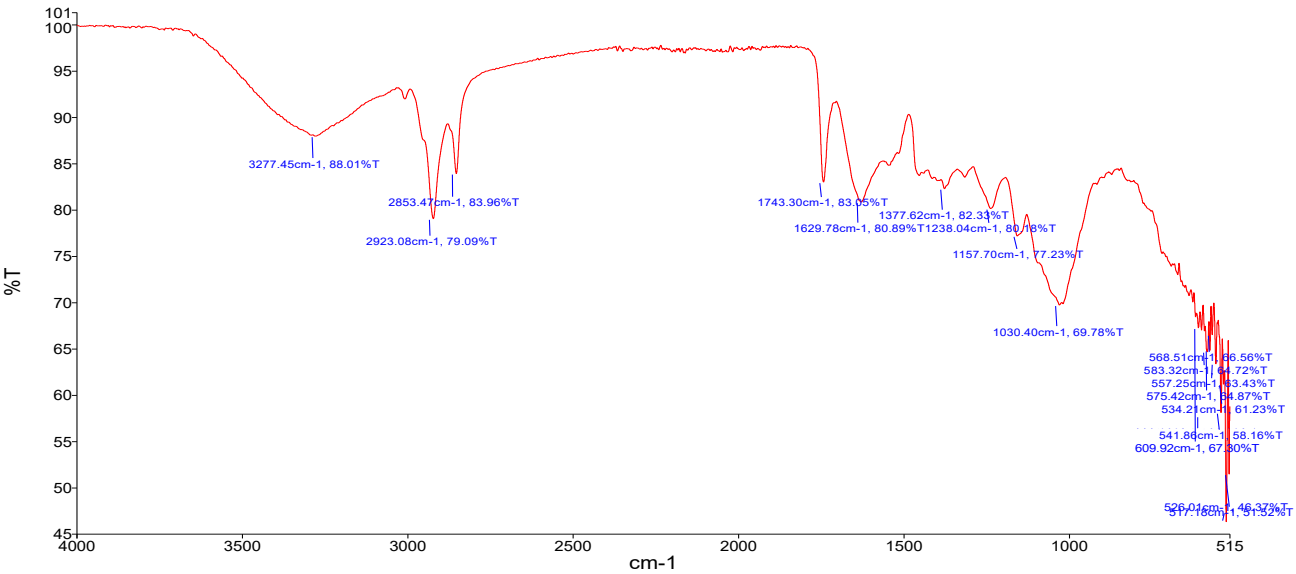


Fig. 3. FT-IR spectra *of Capsicum frutescens var. cerasiforme*.

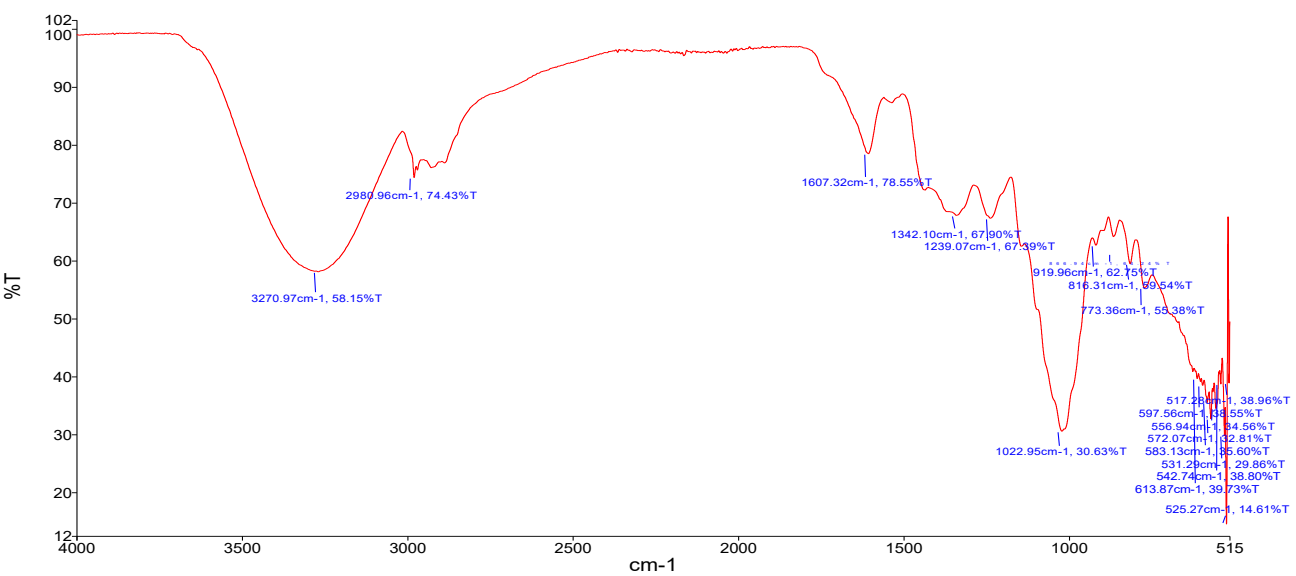


Fig. 4. FT-IR spectra of *Diospyros kaki*.

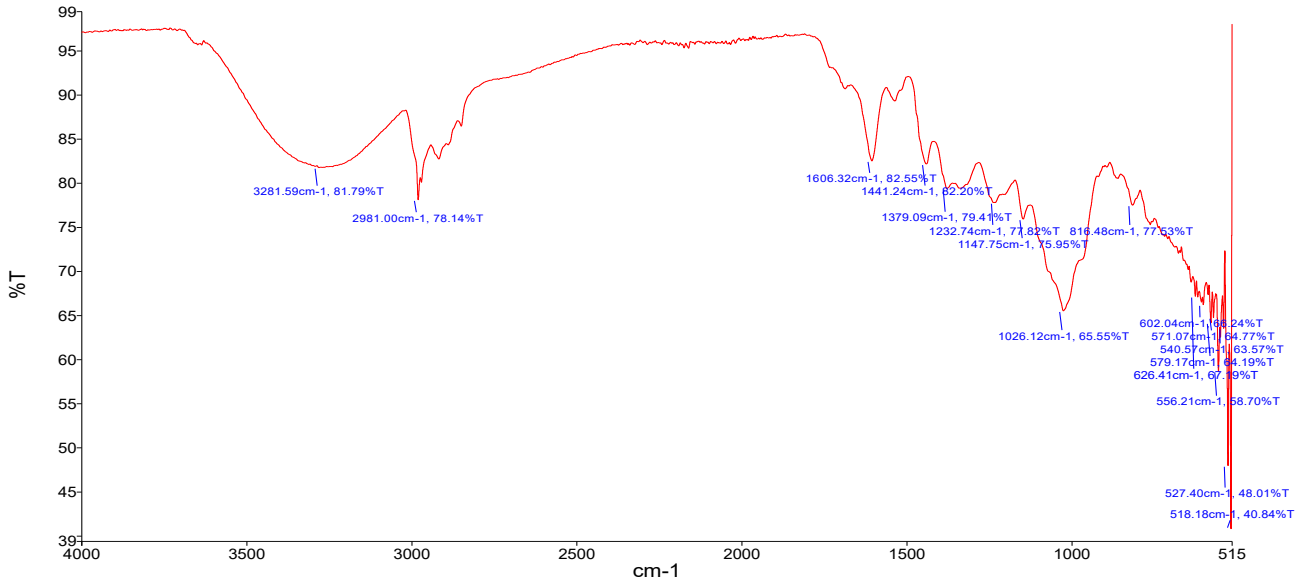


Fig. 5. FT-IR spectra of *Diospyros lotus*.

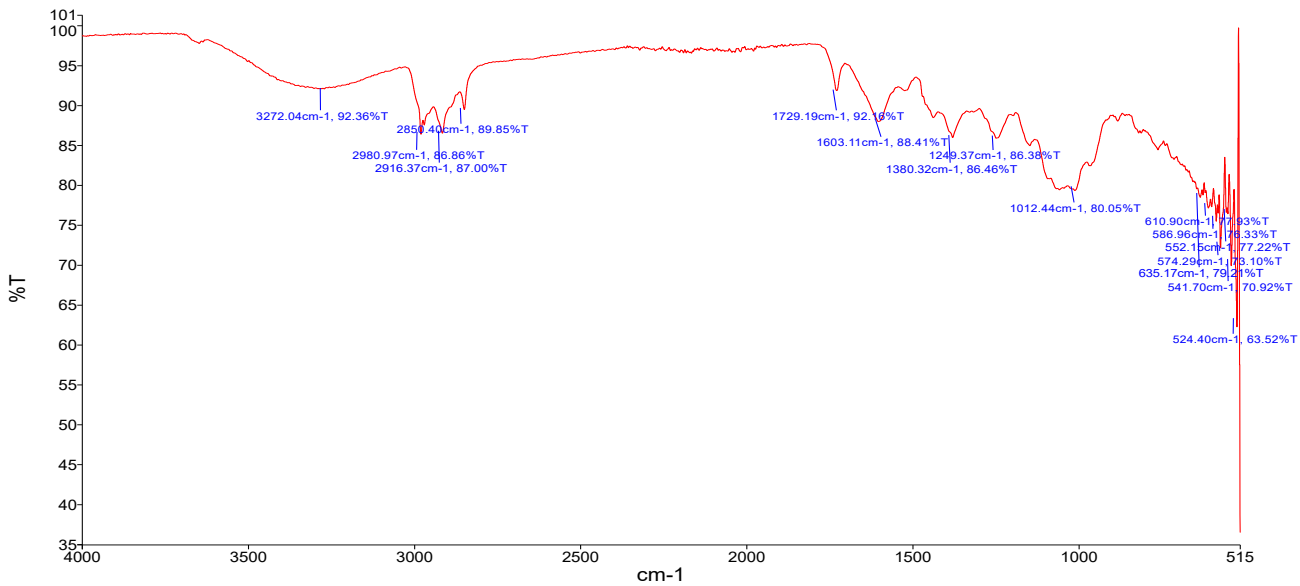


Fig. 6. FT-IR spectra of *Ficus auriculata*.

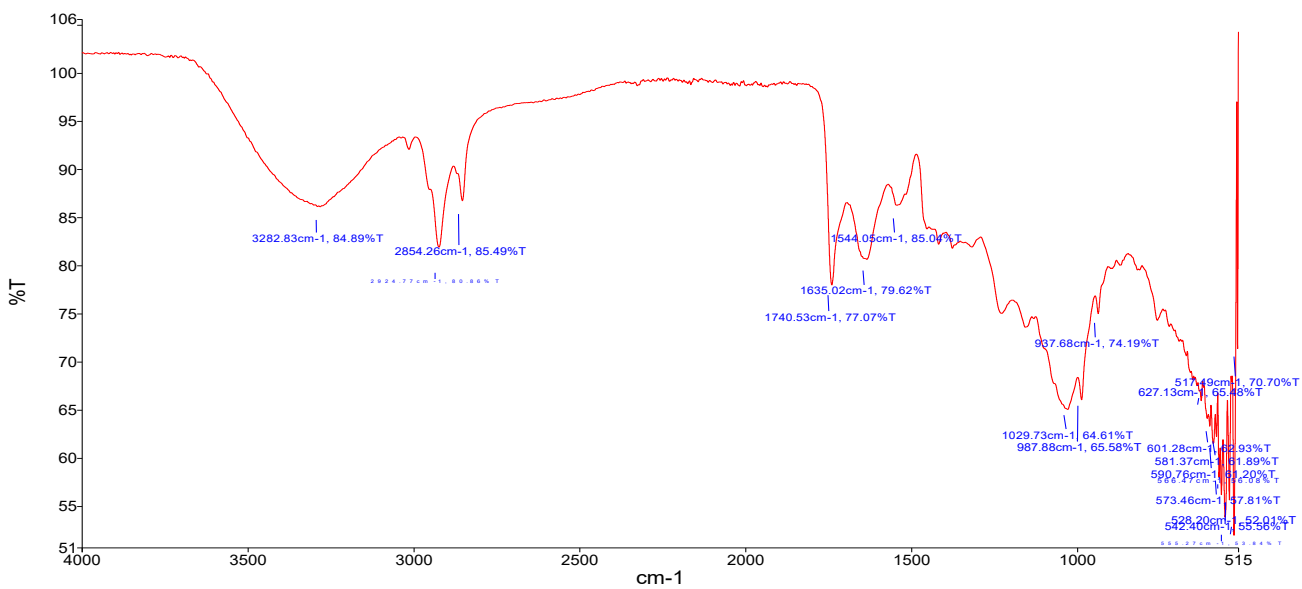


Fig. 7. FT-IR spectra of *Punica protopunica*.

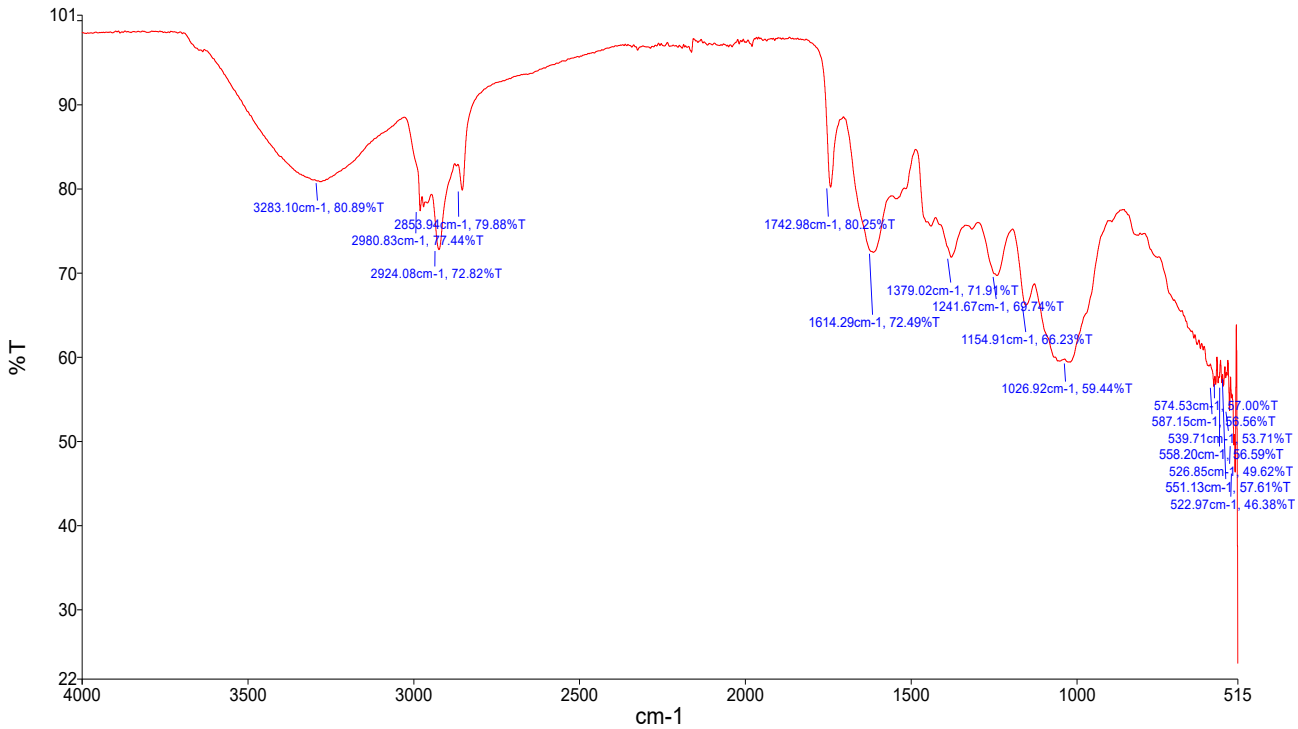


Fig. 8. FT-IR spectra of *Zanthoxylum armatum*.

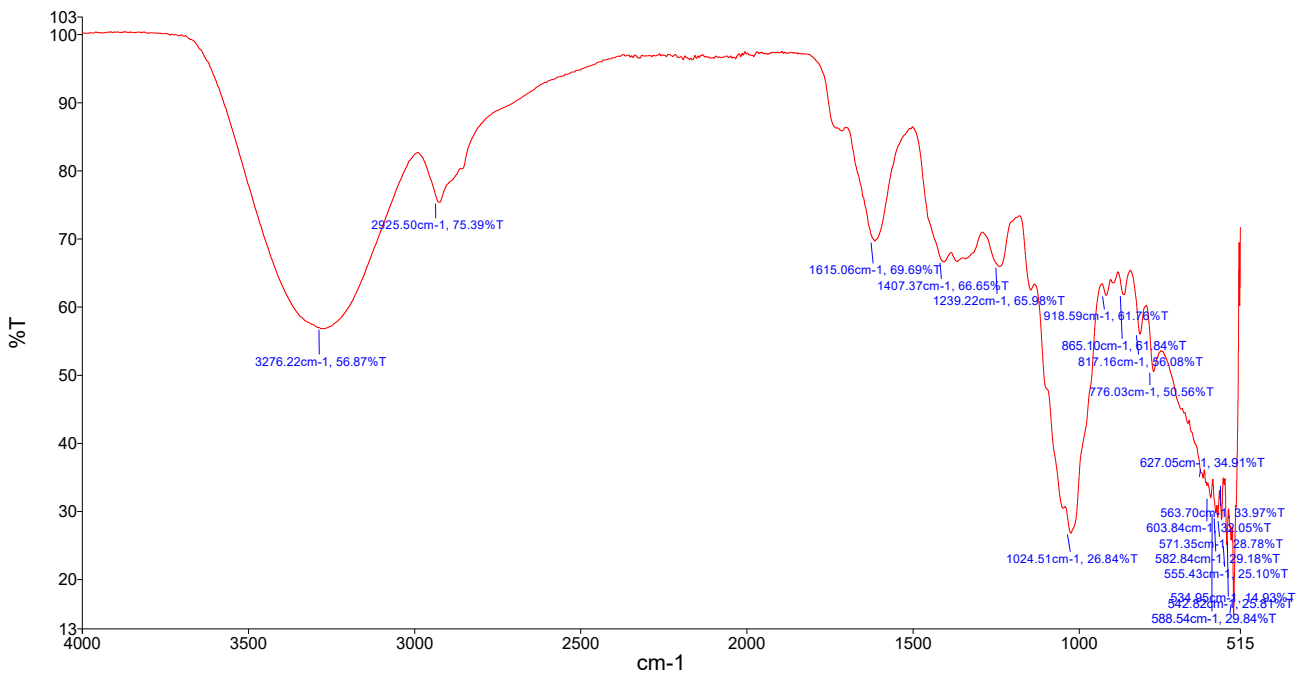


Fig. 9. FT-IR spectra of *Ziziphus jujuba*.

The FTIR spectra of fruit of *Capsicum frutescens* showed the characteristics absorption bands at different wavelengths (Fig. 3). The absorbance at 3277.45cm-1 shows N-H stretching that indicates aliphatic primary amine whereas weak absorption of 2923.08cm-1 was the O-H stretch of alcohol. The 1743.30cm-1 absorption indicates the C=O bonds of esters. Absorption at 1629.78cm-1 represents the N-H bend of amines. The absorbance at 1377.62cm-1 shows the O-H bending of phenol and 1238.04cm-1 was C-N of amines. The absorbance at 1157.70cm-1 represent the C-O of tertiary alcohol. The strong absorption of 1030.40cm-1 represents the C-O stretching that indicated vinyl ether and alkyl aryl ether. The absorption bands between the 690 to 515cm-1 showed the C-Br of halo compounds. The FT-IR spectrum of *Capsicum frutescens* as presented by (Otunola *et al.*, 2017) depicts result that shows the presence of functional group that are similar to our study. They attributed these functional groups to essential phytochemicals.

The FT-IR spectra of fruit of *Diospyros kaki* as shown in Fig. 4 depicts the characteristics absorption bands at different wavelengths. The absorbance at 3270.97cm-1 shows N-H stretching that indicates aliphatic primary amine whereas weak absorption of 2980.96cm-1 is the O-H stretch

of alcohol. The 1607.32cm-1 absorption indicates the C-H bonds of aromatic compound. The absorbance at 1342.10cm-1 shows the O-H bending of phenol and 1239.07cm-1 is C-N of amines. The strong absorption of 1022.95cm-1 represented the C-O stretching the presence of indicating vinyl ether and alkyl aryl ether. The absorbance at 773.36cm-1 indicates the C=C of alkenes. The absorption bands between the 690 to 515cm-1 showed the C-Br of halo compounds. (Reddy, 2019) also reported the presence of phenol in this fruit through FT-IR spectroscopy.

The FTIR spectra of the fruit of *Diospyros lotus* depicted the characteristics absorption bands at 3281.59cm-1, 2981.00cm-1, 1606.32cm-1, 1379.09cm-1, 1232.74cm-1, 1026.12cm-1, 816.48cm-1, and 690-515cm-1 (Fig. 5). The absorbance at 3281.59cm-1 showed N-H stretching that indicates aliphatic primary amine whereas weak absorption of 2981.00cm-1 was the O-H stretch of alcohol. The 1606.32cm-1 absorption indicated the C-H bonds of aromatic compound. The absorbance at 1379.09cm-1 shows the O-H bending of phenol and 1232.74cm-1 was C-N of amines. The strong absorption of 1026.12cm-1 represents the C-O stretching indicating vinyl ether and alkyl aryl ether. The absorbance at 816.48cm-1 indicates the C=C of alkenes. The absorption bands between the 690 to 515cm-1 showed the C-Br of halo compounds. Yue *et al.* (2020) also reported the presence of phenols, alcohols, ethers, fatty acids, hydrocarbons and aromatic compounds in the fruit of *D. lotus*.

The FTIR spectra of fruit of *Ficus auriculata* showed the characteristics absorption bands at 3272.04cm-1, 2980.97cm-1, 2850.40cm-1, 1603.11cm-1, 1380.32cm-1, 1249.37cm-1, 1012.44cm-1 and 690-515cm-1 (Fig. 6). The absorbance at 3272.04cm-1 shows N-H stretching that indicates aliphatic primary amine. weak absorption of 2980.97cm-1 is the O-H stretch of alcohol. The absorption at 2850.40cm-1 is the C-H bond of alkane. The 1603.11cm-1 absorption indicates the C-H bonds of aromatic compound. The absorbance at 1380.32cm-1 shows the S=O stretching of sulphonyl chloride and 1249.37cm-1 is C-N of amines. The strong absorption of 1012.44cm-1 represents the C-F stretching that indicates the presence of fluoro compounds. The absorption bands between the 690 to 515cm-1 shows the C-Br of halo compounds.

The FTIR spectra of fruit of *Punica protopunica* exhibited the characteristics absorption bands at 3282.83cm-1, 2924.77cm-1, 1740.53cm-1, 1635.02cm-1, 1029.73cm-1, 987.88cm-1, and 690-515cm-1 (Fig. 7). The absorbance at 3282.83cm-1 shows N-H stretching that indicates aliphatic primary amine. weak absorption of 2924.77cm-1 is the O-H stretch of alcohol. The absorbance at 1740.53cm-1shows the stretching of esters and aldehydes. The 1635.02cm-1 absorption indicates the C=C bonds of conjugated alkenes. The strong absorption of 1029.73cm-1 represents the C-O stretching that indicates vinyl ether and alkyl aryl ether. The absorbance at 987.88cm-1 indicated the bending of C=C of mono-substituted alkenes. The absorption bands between the 690 to 515cm-1 showed the C-Br of halo compounds.

The FTIR spectra of fruit of *Zanthoxylum armatum* as shown in Fig. 8 shows the characteristics absorption bands at 3283.10cm-1, 2980.83cm-1, 1742.98cm-1, 1614.29cm-1, 1379.02cm-1, 1241.67cm-1, 1154.91cm-1, 1026.92cm-1, 690-515cm-1. The absorbance at 3283.10cm-1 shows N-H stretching that indicates aliphatic primary amine whereas weak absorption of 2980.83cm-1 was the O-H stretch of alcohol. Absorbance at 1742.98cm-1 indicates the C=O bond of esters. The 1614.29cm-1 absorption depicted the C=C bonds of aromatic alkenes. The absorbance at 1379.02cm-1 shows the O-H bending of phenol and 1241.67cm-1 is C-N of amines. The absorption at 1154.91cm-1 indicates S=O of sulphonic acid or sulphones. The strong absorption of 1026.92cm-1 represented the C-O stretching that indicated the presence of vinyl ether and alkyl aryl ether. The absorption bands between the 690 to 515cm-1 shows the C-Br of halo compounds.

The FTIR spectra of fruit of *Ziziphus jujuba* as shown in Fig. 9 presents the characteristics absorption bands at 3276.22cm-1, 2925.50cm-1, 1615.06cm-1, 1407.37cm-1, 1239.22cm-1, 1024.51cm-1, 817.16cm-1, 776.03cm-1, and 690-515cm-1. The absorbance at 3276.22cm-1 showed N-H stretching indicating aliphatic primary amine whereas weak absorption of 2925.50cm-1 is the O-H stretch of alcohol. The 1615.06cm-1 absorption exhibited the C=C bonds of α, β-unsaturated ketones. The absorbance at 1407.37cm-1 shows the S=O stretching of sulphonyl chloride and 1239.22cm-1 is C-N of amines. The strong absorption of 1024.51cm-1 represented the C-O stretching showing the presence of vinyl ether and alkyl aryl ether. The absorption at 817.16cm-1 was the C-Cl stretching of halo compound. The absorbance at 776.03cm-1 indicated the C=C of alkenes. The absorption bands between the 690 to 515cm-1 shows the C-Br of halo compounds.

## Conclusion

The findings emphasized the value of wild fruit species as an affordable nutritional supply for the impoverished in rural areas. Many wild fruits have nutritional value in the form of protein, carbohydrates, or other compounds. The findings also demonstrated some variation in chemical composition, phenolic and flavonoid contents among fruits and also with the previous studies which depends on the area of origin as well as growing conditions. The study of eight wild edible fruits highlights the excellent nutritional value and the potential applications for them as a substitute source of bio-nutrition. These fruits could potentially be most useful as a substitute source of food security to prevent or lessen malnutrition. Additionally, a scheme for agroforestry and farm-forestry may incorporate these wild fruits for domestication. This nutritional assessment can be expanded to further find out the health benefits by employing different other assays and models.

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